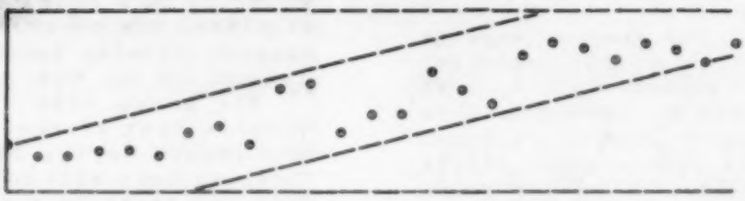
INDUSTRIAL QUALITY CONTROL



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SOCIETY OF QUALITY CONTROL ENGINEERS

IN COOPERATION WITH

THE UNIVERSITY OF BUFFALO

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THE SOCIETY OF QUALITY CONTROL ENGINEERS

ROCHESTER CLINIC

On February 20 the Quality Control Engineers of Rochester, aided by the Industrial Management Council of that city are inaugurating a new type of program in the form of a Quality Control Clinic. The program appears in detail on pages 10 and 11 of this magazine. The Rochester management deserves the highest praise for its initiative in arranging this Clinic. The subject matter is well-balanced and timely. The quality control specialists who will appear on the program are an ample guarantee of an instructive meeting.

S.Q.C.E.

The Society of Quality Control Engineers was born September 18, 1943 and was officially christened when the name was copyrighted on November 7, 1943. Non-the-less its first birthday was actually celebrated January 15, 1945 with an annual meeting attended by about 100 members and guests. The technical part of this meeting consisted of an illustrated talk by Joseph Manuele which is reported elsewhere in this magazine. At the business session action was taken on the amendment proposed in the last issue of this magazine. The amendment having been adopted, the new Executive Board was elected and held its organization meeting on January 25.

The new president is Alfred J. Winterhalter of Colonial Radio Corporation. This highly desirable selection by the Executive Board assures the Society of competent, efficient and aggressive leadership during 1945. Mr. Winterhalter is thoroughly familiar with the objectives and problems of the Society. His choice is a particularly happy one from the point of view of the future of INDUSTRIAL QUALITY CONTROL because he has shared the editorial burden of the magazine since its inception last July.

One action taken by the Executive Board is of sufficient importance to the members of the Society to warrant some comment. It relates to the payment of dues. The Constitution states that all who are trained in quality control procedure, are engaged in quality control operations, or are interested in quality control development are eligible to membership in the Society. These qualifications are sufficiently broad to include anyone who is in position to spread the quality control gospel. In particular, it includes all who have attended quality control classes either at the University of Buffalo or elsewhere. Any of the latter who happen to be located in areas from which they can conveniently attend Buffalo meetings have been and will be welcome as members of the Buffalo Society. It is assumed that those attending University of Buffalo classes will be interested in supporting the Society.

The Executive Board is prepared to implement this assumption in the immediate future by sending a bill for dues for the calendar year, 1945, to all whose names appear on the list of potential members. The Board believes that it is entitled to expect a 100% response to this request for funds with which to carry on the rather ambitious program of technical sessions that was outlined at the Board meeting. This is in addition to the magazine which is now being mailed to all who have completed one of the several quality control courses offered by the University either on campus or in the plants.

The Board also took action to meet inquiries from several members of the Society who joined during the latter part of 1944. These members will be billed for a half year's dues now to carry their membership to the end of 1945. In the future, those who become eligible for membership after July 1 will be charged one-half the annual dues for the remainder of the year in which they affiliate. The Board is very specific in ruling that the half year dues rate is available only to those who become eligible for membership after July 1. It does not apply to those who were eligible earlier in the year but neglected to affiliate. Although subscribers to INDUSTRIAL QUALITY CONTROL in other areas are not directly concerned with the plan of the Buffalo Society, they may have kindred problems in their several areas. Our subscribers will be interested in the information that they now number more than 400, located in thirty-one states, Canada and England. At the present time the non-member subscribers are bearing about one-half of the cost of publication and the members the other half.

Subscriptions are being received at a rate which indicates that our goal of 1000 subscribers by the end of the first year of publication will be realized. The increase in size from 16 pages to 20 pages inaugurated with the November issue will be continued.

Material for publication is arriving from time to time. This gives us something of a backlog for future issues. None-the-less we would like to have stories of quality control installations now in operation in plants of members of the Society or subscribers to the magazine. These stories of difficulties resolved, and obstacles overcome by men working in plants provide the most valuable type of information to fellow quality control operators. In fact, the exchange of information of this sort was set forth originally as one of the chief reasons for the existence of INDUSTRIAL QUALITY CONTROL.

THE QUALITY HABIT

Harry E. Paddock
Quality Control Engineer
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Eastman Kodak Co.

I believe that we all recognize that through continuously following a certain course of action, or way of thinking, over a period of time we gradually build up habits which govern our thoughts and actions.

In selecting people for work in industry, an attempt is made to select people whose habits indicate that they may be trained to acquire certain industrial habits which will make them good workmen. In order to develop good workmen from this selected personnel, a training program must be arranged which will motivate these people to form desirable industrial habits.

For example, I know of an instance where it is necessary ti keep an entire manufacturing division scrupulously clean. From the time an employee first enters this division he is constantly reminded of the necessity for cleanliness of person, cleanliness of clothing, and of keeping his equipment and working space clean and orderly. Through continuous training along these lines the employees of this division soon acquire the habits of order and cleanliness. This cleanliness habit, when acquired by all the employees, accomplishes much more in keeping up the necessary cleanliness standard than could be accomplished by any possible combintion of supervision and janitor service without the cooperation of all the employees.

I believe employees can be trained in a similar manner to acquire the quality habit. If you examine the quality of work turned out by a group of operators engaged in an operation where quality depends upon the individual operators skill, you will find that there is a wide spread in the quality range. Although it is sometimes assumed that better quality limits production, you will frequently find that some of the operators producing maximum quantity have also turned out product at the highest quality level of the group. This leads to the opinion that operators can be trained to produce high quality product economically.

If a plant is interested in improving the over-all quality of its product, one of the first and most important steps should be to set up conditions for training its people to acquire the quality habit. The quality habit involves much more than the performance of the individual operator and should extend from top management throughout the entire organization. For example, whenever changes in equipment, process, or method are contemplated, the first concern of all interested people should be the possible effect of the change on the quality of the product.

It is most important that the management be definitely interested and ready to support consistently a quality improvement program before attempting to organize quality control groups and start a training program. It is natural for departmental supervision and personnel to display the greatest interest in those management functions in which the management consistently demonstrates an active interest. This places upon the management the responsibility for considering carefully the need for quality improvements in their product, or for a reduction in their processing scrap, before authorizing the organization of a centralized quality control department.

Assuming that the management is keenly interested and will support the program, I believe that the following plan is a rather simple and effective method of developing the quality habit throughout an organization, whether it be large or small.

The first step is for the management to authorize the organization of an independent cooperative Quality Control Department which will report directly to the top management in charge of the production activities of the plant. The duties of the Quality Control Department include:

1. Stimulating and maintaining interest in the quality program.

2. Coordinating the quality control efforts of the several departments. This includes making recommendations or obtaining the management's decisions in questions of interdepartmental quality problems.

3. Investigating reasons for all major quality failures and providing the required

follow-up to see that the necessary changes in equipment, method, or process are adopted and maintained to minimize the probability of the recurrence of the defects.

It is very important that the Quality Control Department bear in mind that its purpose is to assist the plant management in producing quality product, rather than to acquire personal credit for their activities. When representatives from any staff department start activities in a production department there is apt to be suspicion on the part of some of the departmental personnel that the staff people are there to obtain more than their share of the credit for improvements resulting from mutual suggestions or effort. This condition limits the cooperation necessary for obtaining the best over-all result. The Quality Control Department must demonstrate a policy of rendering service without regard for personal credit if it is to obtain the necessary cooperation to carry on a successful quality program over long periods of time.

In selecting the personnel of the Quality Control group, it is desirable that the key men have a type of technical training which has equipped them to analyse and solve special problems. It is also desirable that these men have a variety of industrial experience before starting quality control work. It is most important that they have the ability to make good contacts and develop cooperation.

It is a good plan to recruit departmental contact people from the inspection group of the Production Department if possible. These people should be chosen from a group recommended by their superintendent as ones in whom he places confidence for job knowledge and cooperation and who have earned the respect of the department personnel. It is important that such positions within the Quality Control Department be made attractive enough to represent a promotion for experienced inspection people and that the superintendent of the Production Department have enough interest in quality control objectives to motivate him to recommend the type of people best fitted for the work.

One of the most important functions of the Quality Control Department is to keep production superintendents informed of their quality requirements and quality failures which are detected in subsequent inspection units, or in some instances may have reached the trade.

One method of keeping the production superintendents informed is for the Quality Control Department to set up a defect investigation procedure. The first step in this procedure is to arrange cooperative contacts with all plant inspection and testing units. Arrangements must be made with these units to keep the Quality Control Department informed of the types and quantities of defects detected daily. This includes selecting typical defect samples for the Quality Control Department.

The Quality Control Department makes an immediate study of these defect data obtained from the inspection and testing units to determine whether it is a new defect, or recurrence of an old one; whether it is a defect which definitely occurred in some manufacturing process; resulted from a combination of causes; or whether the cause is unknown. The prerequisite for such analysis is a thorough knowledge of the plant's defect hazards and the characteristics of known defects.

After completing its study of the data, the Quality Control Department prepares a defect investigation report which includes a statement of its preliminary investigation, the quantities involved, and typical samples of the defect. This report is then sent direct to the superintendent of the Production Department in which the defect occurred.

The superintendent is asked, after reviewing the data, to conduct his own departmental investigation to determine whether the defect occurred as a result of personnel, equipment, method, or inspection failures.

The investigation by the Production Superintendent accomplishes the following objectives:

1. It demonstrates to all his people his interest in producing a quality product.

2. It gives him the opportunity of contacting the people directly concerned and obtaining first hand knowledge of the circumstances and conditions leading to the occurrence of the defect.

3. It gives the superintendent the opportunity of being the first to contact the management with his report of the departmental circumstances in connection with the defect and to discuss with them the corrective measures

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which have been suggested by his people for the elimination of the defect. Through these management contacts, the management also has an opportunity to demonstrate directly to the superintendent the degree of its interest in his quality problems.

4. It impresses on all his people the necessity for keeping posted on all of the conditions which may affect the quality of the product.

5. It gives him an opportunity to call in specialists to study the problem and suggest changes.

6. It removes practically all normal objections to full cooperation with the Quality Control Department.

The production superintendent should have sufficient on-the-spot inspection under his direct supervision to detect most of his department's defects at their source. This practice places direct responsibility for defects and encourages the development of inspection functions as a part of the production operators work. Most production operators have an opportunity to devote a portion of their time to inspection and as they are closest to the sources of trouble they can avoid much scrap by reporting the immediate sources of quality failures. The production operators naturally perform this inspection function much better when reporting to representatives of their own department.

The Quality Control Department should keep the production superintendents informed of the necessity for maintaining quality standards through keeping them acquainted with trade reactions, showing them the results of quality tests, and pointing out how new uses or changes in trade requirements may necessitate a change in quality standards.

After the production superintendent completes his investigation, he fills out his part of the defect investigation report, which includes a statement as to whether he has actually located the source of the defect and what corrective measures are being taken to minimize the probability of recurrence. This report is then sent to the Quality Control Department for its review and to be used as a basis for assigning departmental responsibility for the defect.

Now, suppose that the superintendent, after investigation, disclaims responsibility for the defect. In that case the Quality Control Department head assumes the position of an umpire in baseball. He reviews all of the available data and assigns the departmental responsibility in accordance with the evidence in the case. His decision stands unless the department to which the responsibility is assigned subsequently produces proof that the decision should be changed.

It is very important that the departmental superintendent accept this decision and take action under the assumption that it is his trouble up to the point where the actual source of the defect has been proven to be in another department. If you do not set up a plan for assigning responsibility for all defects, it weakens the general plan and encourages the practice which is commonly known as "passing the buck."

It is obvious that the success of this plan depends upon the attitude and training of the head of the Quality Control Department who is to act as umpire. He must first of all demonstrate that he is impartial, basing his decisions on the available evidence without any consideration of personal preference for any particular department. He must also have a knowledge of defect characteristics and plant hazards which will enable him to make decisions which prove to be correct in most instances.

After the assignment of responsibility without conclusive proof of the source of a defect, the Quality Control Department should encourage a cooperative study of the defect by all interested people to see if the actual source of the defect can definitely be determined. Definite acceptable assignment of responsibility helps the superintendents in working out and applying corrective procedures.

In quality problems involving two or more departments, the Quality Control Department should act as chairman of a committee which has representation from all the departments interested in the problem. This committee should obtain and discuss all available data and attempt to reach a decision on a plan of action which will solve the problem from the viewpoint of obtaining the best over-all quality of the finished product.

If these plans for investigating and assigning responsibility for all defects are consistently followed, it will bring about contacts

(Continued on Page 17)

THE ANALYSIS OF SAMPLING PLANS IN RECEIVING INSPECTION

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Much has been written about the advantages of scientific sampling plans in receiving inspection. The need for such plans rests on a two fold recognition that the quantities of materials received precludes the use of old style screening inspection and that most of the sampling plans that have been substituted are inadequate because, like Topsy, they "just grew". These sampling plans do not provide reasonable protection to the purchaser against the acceptance of poor quality lots. They do not provide reasonable protection to the producer against the rejection of good quality lots. Yet quality control operators have experienced considerable difficulty in demonstrating to supervision of receiving departments the inadequacy of these so called simple plans. This article contains an explanation of the steps in the analysis of one of these plans.

The plan selected is widely used in different industries. It is a percentage plan and may appear with a variety of percents according to the amount of inspection considered necessary and the quality of material which a plant desires to have going into the receiving crib. Specifically, the plan at hand is stated "Take a 10% sample: if the sample is not more than 2% defective, accept the lot." Nothing is stated concerning the action to be taken if the sample is more than 2% defective, but presumably the lot is to be returned to the vendor for screening or to be screened by the purchaser.

Point I. This plan will not assure that accepted lots contain at least 98% good material. Simon* has demonstrated that small samples tend to misrepresent the lots favorably. Since in this plan the sample size is directly proportional to the lot size, it is a simple matter by use of Simon's chart, $.5 = I_Q$, to show the most likely fraction defective of various lot sizes where the sample is 2% defective. Table I also includes the range of percent defective that can be expected to be exceeded by only one in ten lots on the high side and the low side.

* An Engineer's Manual of Statistical Methods, Leslie E. Simon, John Wiley and Sons, New York 1941.

Many lots will be accepted by inspecting samples which have less than 2% defective. This will reduce the average of accepted lots below the averages shown in the fourth column of the table. But the table shows the average and range of fraction defective of lots, all of which are acceptable under the plan: hence the conclusion that material much more than 2% defective will be accepted. Specifically, if the lot size is 100, there is a 1 in 10 probability of taking lots that are 19% defective. On the other hand, with lots of 5000 to 10,000 the same probability limits

TABLE I: MOST LIKELY LOT FRACTION DEFECTIVE AND 80% RANGE OF FRACTION DEFECTIVE FOR VARIOUS LOT SIZES WHEN SAMPLES ARE 2% DEFECTIVE.

LOT SIZE	SAMPLE SIZE (10% of lot)	ACCEPTANCE NUMBER (2% of sample)	LOT FRACTION DEFECTIVE		
			THAT IS MOST LIKELY or AVERAGE	THAT WILL BE EXCEEDED BY 90% of LOTS	THAT WILL BE EXCEEDED BY 10% of LOTS
100	10	0*	.060	.009	.190
500	50	1	.032	.010	.075
1000	100	2	.026	.011	.051
1500	150	3	.024	.012	.043
2000	200	4	.023	.012	.039
5000	500	10	.021	.014	.031
10000	1000	20	.020	.015	.026

* Actually .2 of a defective.

the defectives to about 3%.

Point II. The quality of lots accepted under the plan will be little better than the quality offered. To demonstrate this point a bead experiment was set up to duplicate as nearly as possible actual conditions in a receiving department. Several thousand beads were placed in a box in the proportion, 97% white, 3% red. This represents a production process. From this box lots of 500 beads each were drawn in a random manner. It will be noted from Table I that lots of 500 are likely to be on the average 3.2% defective under the given sampling plan. This is the reason for setting the large box of beads at 3% defective. The distribution of 30 lots of 500 is shown at the left of Table II. Two lots had 9 defectives, or were 1.8% defective;

at the other extreme one lot had 20 defectives, or was 4% defective. This is a typical distribution of lots which are on the average 3% defective. In fact in drawing these 15,000 beads, 434 red ones were included for a process average of 2.89%.

fective. From the five lots containing 15 defectives, one sample was free of defects, one contained 1 defect, another 2 defects, another 3 defects and another 4 defects. At the bottom of these columns is shown the number of samples having 0, 1, 2, 3, and 4 de-

TABLE II*: RECORD OF DRAWING OF LOTS OF 500 BEADS FROM A BOX CONTAINING A LARGE NUMBER OF BEADS WHICH WERE 3% RED (Defective), SAMPLES OF 50 FROM THE LOTS OF 500, AND DISPOSAL OF THE LOTS (Acceptance or Rejection) ACCORDING TO NUMBER OF DEFECTIVES IN THE LOTS.

LOTS OF 500			SAMPLES OF 50						DISPOSAL OF LOTS			
									ACCEPTED		REJECTED	
NO. DEFECTIVE	NO. of LOTS	NO. of DEFECTIVES	PERCENT DEFECTIVE	0	2	4	6	8	NO. of LOTS	NO. of DEFECTIVE PIECES	NO. of LOTS	NO. of DEFECTIVE PIECES
			NO. DEFECTIVE	0	1	2	3	4				
9	2	18		1	1				2	18		
10	1	10		1					1	10		
11	1	11			1				1	11		
12	4	48			2	1	1		2	24	2	24
13	3	39			2	1			2	26	1	13
14	3	42			2	1			2	28	1	14
15	5	75		1	1	1	1	1	2	30	3	45
16	2	32		1		1			1	16	1	16
17	6	102		4		2			4	68	2	34
18	1	18		1					1	18		
19	1	19				1					1	19
20	1	20			1				1	20		
TOTAL	30	434		9	10	8	2	1	19	269	11	165

Fraction Defective

Lots offered = $\frac{434}{15000}$ = .0289

Lots accepted = $\frac{269}{9500}$ = .0283

Lots rejected = $\frac{165}{5500}$ = .0300

	3% defective or less	Over 3% defective
Lots accepted	12	7
Lots rejected	7	4

37% of accepted lots were more than 3% defective.

64% of rejected lots were 3% defective or less.

* The form of this table is taken from Dr. Holbrook Working, Chief of Quality Control Program, Office of Production Research and Development, War Production Board.

From each lot of 500 a sample of 50 was taken at random (10% sample). The results are recorded in the center section of Table II. Thus from the two lots of 500 which contained 9 defectives, one sample of 50 contained no defectives and the other contained one defects, respectively. Since samples of 50 must contain not more than one defect to be acceptable, there are 19 accepted lots and 11 rejected lots.

The disposal of these lots in detail is shown at the right of Table II. The 19 accept-

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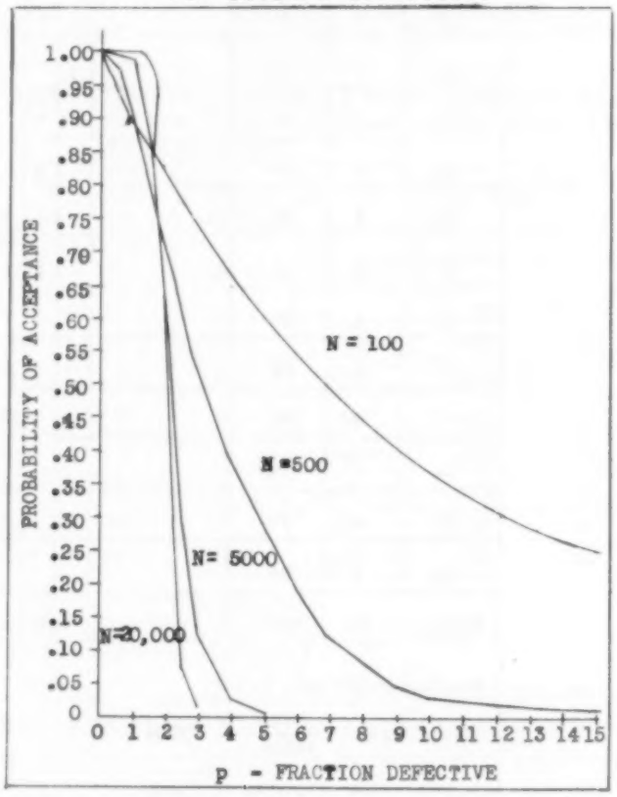
ed lots contained 269 defectives and the 11 rejected lots contained 165 defectives. The summary appears below the table. The lots offered were 2.89% defective, the lots accepted were 2.83% defective, the lots rejected were 3% defective: thus the conclusion that the lots accepted under this plan are very little better quality than the lots offered. It follows, of course, that the quality of rejected lots is very little poorer that that offered. In short, this plan does not separate good quality lots from poor quality lots of incoming materia'. Money spent for this type of inspection could be saved because the purchaser would have about the same quality of material in stock, if he simply accepted whatever was offered by the vendor. The most that can be said in favor of this plan is that it has a fair probability of detecting a highly defective lot, providing the lot is not too small.

This demonstration has been set up for lots of 500. There is nothing in the conclusions drawn that is peculiar to either lot size or sample size. The same weakness of the plan would appear regardless of the lot size chosen.

Point III. This plan does not afford reasonable protection to the purchaser against the acceptance of poor quality lots: it does not afford reasonable protection to the producer against the rejection of good quality lots. This point can be demonstrated by reference to the disposal of lots in Table II. Let us say that the purchaser is willing to accept material which is 3% defective. The reader will recall from Table I that this will be the average quality of lots of 500 accepted under the proposed plan. The subtabulation appended to Table II shows that of the 19 lots accepted, 12 were 3% defective or less, while 7 were over 3% defective. Thus 37% of the accepted lots were poorer than the acceptable quality.

From the point of view of the producer the situation is even worse. Seven of the eleven rejected lots were of acceptable quality, while only 4 lots were of poorer quality. Thus 64% of the lots would prove on detailing to be not more than 3% defective. This is the type of inspection which creates the endless disputes between vendor and purchasing department. The blame is always saddled on the receiving inspection department, purchasing loses faith in inspection, inspection accuses purchasing of protecting the vendor, the vendor is tied by government allocations, and the legal department has another case. All of this could be avoided if the supervision of receiving department was willing to listen to the quality control operator's proposal to replace the so-called simple sampling plans such as this one by a scientific plan designed to provide constant protection to the consumer against the acceptance of poor quality lots and constant protection to the producer against the rejection of good quality lots.

CHART I: PROBABILITY OF ACCEPTANCE AS A FUNCTION OF FRACTION DEFECTIVE FOR SEVERAL LOT SIZES.



Point IV. The degree of protection for both purchaser and vendor under this plan varies with lot size. In particular, the protection for both is good for very large lots, but the reverse is true for small lots. This point can be explained most easily by developing the operating characteristic of the plan. This is shown in Table III and Chart I for four lot sizes, 100, 500, 5000 and 20,000.

If material arriving in lots of 100 is inspected by the given plan, the results will be as indicated on Chart I. If the vendor can

maintain a process average of not more than 1.5% defective, he can expect in the long run that not more than 14% of such lots will be rejected. But this is not satisfactory to the vendor, who would be led to believe from the 2% reject level used in the sampling plan that material of that quality should suffer only occasional rejections. Yet the curve shows that samples which are 2% defective will lead to rejection of the lot 18% of the time. The protection to the purchaser is even less satisfactory. Let us assume that he is willing to take a nominal risk of accepting material which is 5% defective. The chart shows that the risk actually is 61% of accepting 5% defective material and that the usual nominal 10% risk is reached at material which is over 20% defective. The plan gives wholly unsatisfactory results for both vendor and purchaser where lots are small.

TABLE III: PROBABILITY OF ACCEPTANCE OF LOTS OF FOUR SIZES ACCORDING TO FRACTION DEFECTIVE FOUND IN THE SAMPLE.

FRACTION DEFECTIVE of SAMPLE	PROBABILITY OF ACCEPTANCE* of LOTS of			
	100 n=10; c=0	500 n=50; c=1	5000 n=500; c=10	20,000 n=2000; c=40
.001	.990	.999	1.000	1.000
.005	.951	.974	1.000	1.000
.010	.905	.910	.986	1.000
.015	.861	.826	.862	.968
.020	.819	.736	.583	.542
.025	.779	.645	.297	.086
.030	.741	.558	.118	.004
.04	.670	.406	.011	
.05	.607	.287	.001	
.06	.549	.199		
.07	.497	.136		
.08	.449	.092		
.09	.407	.061		
.10	.368	.040		
.12	.301	.017		
.15	.223	.005		
.20	.135			
.30	.050			

* All probabilities obtained from "Poisson's Exponential Binominal Limit" E.C. Molina, N.Y., D.Van Nostrand Company, 1943.

Another curve on the chart shows the operating characteristic of the sampling plan where material is received in lots of 500. If the vendor can maintain a process average of 1.5%, he can expect not more than 17% rejections, and 26% of 2% material is likely to be returned. This is obviously objectionable from the vendor point of view. The situation from the purchaser side is better than for smaller lots, but still unsatisfactory. If 5% material is received, 29% of it will be accepted. The 10% nominal risk applies to material which is a little less than 8% defective. But too much poor quality material will be accepted when lot size is 500.

Another curve on the chart shows the operating characteristic for lots of 5,000. The vendor can expect to lose 14% of lots which produce samples that are 1.5% defective and 42% of 2% lots Clearly this is a situation which will cause friction between vendor and purchaser. On the other hand the protection to the purchaser against the acceptance of poor quality lots is good. He takes about the usual risk of accepting 3% material and only slight risk of getting 4% and 5% material. For lots of 5,000 this sampling plan is heavily loaded against the vendor and in favor of the purchaser.

Finally the chart contains the operating characteristic of the plan when applied to lots of 20,000. If the vendor can keep his process average at 1.5% or less, he will encounter only occasional rejections; only 32 in 1,000 lots. But 2% material will be rejected 46% of the time. The purchaser is now well protected. He takes only a nominal risk of accepting material as much as 2.5% defective and practically no risk of getting 3% material.

These operating characteristic curves are ample evidence that under this plan protection to both vendor and purchaser varies with lot size. So long as the vendor can maintain a process average of not more than 1.5% defective, he probably can live with this plan; certainly he cannot live happily except by shipping very large lots If his process average should increase to 2% defective, he would be well advised to shift immediately to the shipment of very small lots. The purchaser's situation is somewhat different. The plan does not protect him for lots of 500 or less it does protect him amply for lots of 5000. An inverse solution of the Poisson exponential shows that he would take a 10% risk of getting material 5% defective when lot size was about 1150.

(Continued on Page 15)

INDUSTRIAL QUALITY CONTROL

QUALITY CONTROL CLINIC

sponsored by

The Quality Control Engineers of Rochester

(Affiliated with the Industrial Management Council of *Rochester, N. Y.*)

TUESDAY - February 20, 1945

At

Chamber of Commerce
55 St. Paul Street
Rochester, N.Y.

—— PROGRAM ——

12:00 M	Registration	
12:15 p.m.	Luncheon	
	Speaker:	M. Herbert Eisenhart, President Bausch and Lomb Optical Company
	Subject:	"Top Management Views Quality Control"
	Presiding:	Halsey Kent, Vice-President Quality Control Engineers
2:00 p.m.-4:30 p.m.	Quality Control Clinics (Schedule on Page 11)	
4:30 p.m.-6:00 p.m.	Recess	
	Gage Exhibits	
6:15 p.m.	Dinner	
	Greeting and Comment:	Lewis B. Swift President Taylor Instrument Companies and Chairman of the Industrial Management Council
	Summary of Clinics:	Martin A. Brumbaugh School of Business Administration, University of Buffalo.
	Speaker:	George D. Edwards, Director of Quality Assurance Bell Telephone Laboratories, New York City
	Subject:	"The Future of Quality Control"
	Presiding:	Alfred L. Davis, President Quality Control Engineers

All persons expecting to attend please notify the Industrial Management Council at the address above, indicating the meal reservations desired and the clinic preferred. This is necessary in order that adequate arrangements can be made.

SCHEDULE OF CLINICS

1. *Subject:* "Installing a Quality Control System"

   Chairman: George Herrold, Chief Inspector, Colonial Radio Corporation, Buffalo, N.Y.

2. *Subject:* "The Function of Statistics in Process Quality Control"

   Chairman: Edwin G. Olds, Chief Statistical Consultant, Office of Production Research and Development, Washington, D. C.

3. *Subject:* "Single Versus Double Sampling for Acceptance Inspection"

   Chairman: John W. W. Sullivan
   Member of Staff, Hill and Knowlton, New York City
   formerly Chief of Inspection, Industrial Division, Cleveland Ordnance District.

4. *Subject:* "Quality Control as a Cost Reduction Instrument"

   Chairman: Ralph E. Wareham, Director of Quality Control, General Electric Company, Schenectady, N.Y.

5. *Subject:* "Application of Control Charts to Screw Thread Problems"

   Chairman: Richard W. Coolbaugh, Assistant Chief Inspector, Easy Washing Machine Company, Syracust, N.Y.

6. *Subject:* "Quality Control thru Gage Control"

   Chairman: Clifford A. Wallace, Superintendent of Quality, Camera Works, Eastman Kodak Company, Rochester, N.Y.

7. *Subject:* "Recent Developments in Gaging Practice"

   Chairman: Chauncey G. Newton, Manager, Small Tool and Gage Department, Pratt and Whitney Company, Chairman, Rochester Chapter, American Society Tool Engineers, Rochester, N.Y.

8. *Subject:* "Methods of Reporting Quality Performance to Management"

   Chairman: William Kerr, General Sales Manager, Spencer Lens Company, Buffalo, N.Y.

9. *Subject:* "Role of Inspection in Development of New Product"

   Chairman: C. E. Stines, Chief Inspector, National Cash Register Company, Dayton, Ohio.

NEW DEVELOPMENTS

In this section of each issue is presented one or more new developments in the field of Quality Control

DEVELOPMENT OF REJECT LIMITS FOR MEASUREMENTS

Alfred J. Winterhalter
Colonial Radio Corporation
Buffalo, N.Y.

INSPECTION OF A PRODUCT AT THE POINT OF PRODUCTION.

Depending upon the organizational set-up of a plant, the product of a process goes to the next stage of manufacture or to the customer without inspection, with 100% inspection, or with an inspection on a sampling basis. Too frequently inspection is performed with snap gages and valuable information is lost through failure to measure and record the measurements. Knowledge of the average, the standard deviation, and the frequency distribution is of great value to the trained operator.

Three conditions obtain when comparing the frequency distribution with the specification limits:

1. Where the dispersion of the universe exceeds the specification range.
2. Where the dispersion of the universe equals the specification range.
3. Where the dispersion of the universe is less than the specification range.

With the first condition scrap is constantly produced, necessitating a change in process or 100% inspection. With the second condition, the pieces produced are within specification limits so long as the average is perfectly adjusted. There can be no variation of the process to produce a shift of the average. With the third condition there is room for a shift of the process average and/or dispersion without producing scrap.

When working under the terms of the third condition one should not fail to investigate points falling outside of the limits of the control chart. However, in many cases, it is not necessary to stop production or rework the tools with the attendant economic loss. The process may be permitted to shift until there is danger of producing scrap.

The positions of the lower and upper three sigma limits on a control chart have a definite relationship to the $\bar{X}'$ of the frequency distribution. The exact position of these limits is dependent upon the sample size.

Distance "c" in Figure I is equal to $A\sigma'$ and distance "d" is equal to $3\sigma' - A\sigma'$. Since the control limits are given by $\bar{X}' \pm A\sigma'$ or $\bar{X}' \pm A_2R'$:

$$A\sigma' = A_2R'$$

$$\sigma' = \frac{A_2R'}{A} = \frac{R'}{d_2}$$

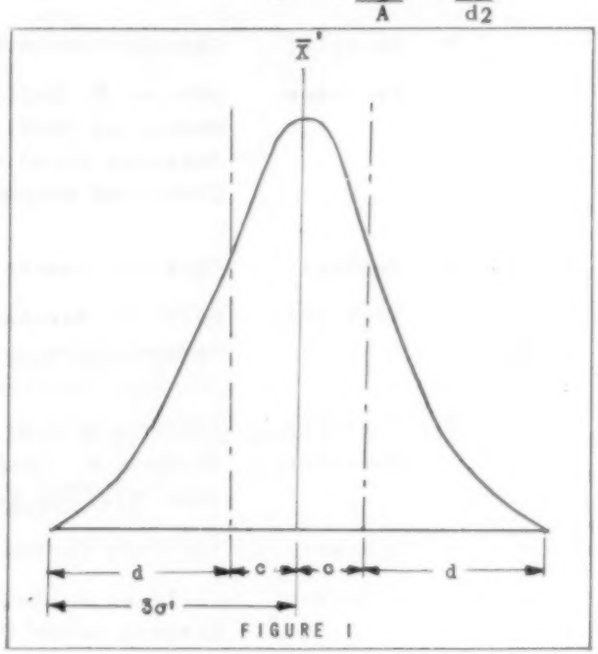


FIGURE I

Substituting $\frac{R'}{d_2}$ for σ' in $3\sigma' - A\sigma'$, we have $d = \left(\frac{3}{d_2} - A_2\right) R'$. This form is more convenient to use than the one involving σ'. Let the factor $\left(\frac{3}{d_2} - A_2\right)$ equal "b". In Table I, values of "b"* have been computed

TABLE I: VALUES OF b AS A FUNCTION OF SAMPLE SIZE

SAMPLE SIZE n	"b"	SAMPLE SIZE n	"b"
4	.728	10	.667
5	.713	11	.660
6	.701	12	.655
7	.690	13	.650
8	.681	14	.646
9	.673	15	.641

* In "A First Guide to Quality Control For Engineers" published by the British Ministry of Supply this same constant (M) is developed for a similar application. The values are not identical because the reference employs 3.09 standard deviations for action limits.

for sample sizes of four to fifteen inclusive.

As long as the averages and the ranges of the measurements fall within the control limits of the charts, only twenty-seven units per 10,000 are likely to fall outside the ± three standard deviation limits of the lot universe. If control is not indicated on the chart of averages but if the lower specification limit plus bR' or the upper specification limit minus bR' is not exceeded, and if control is indicated by the range chart, the risk is nominal of finding pieces falling outside of specification limits. The process is out of control and should be investigated as usual but it is not necessary to stop the process or detail the lot. By the use of the limits, Upper Reject Limit (URL) and Lower Reject Limit (LRL), on the $\bar{X}'$ control chart, means are available to determine when the lot must be detailed. These limits are computed as follows:

URL = Upper specification limit - bR'

LRL = Lower specification limit + bR'

An example will serve to illustrate the application of the foregoing. In Figure II

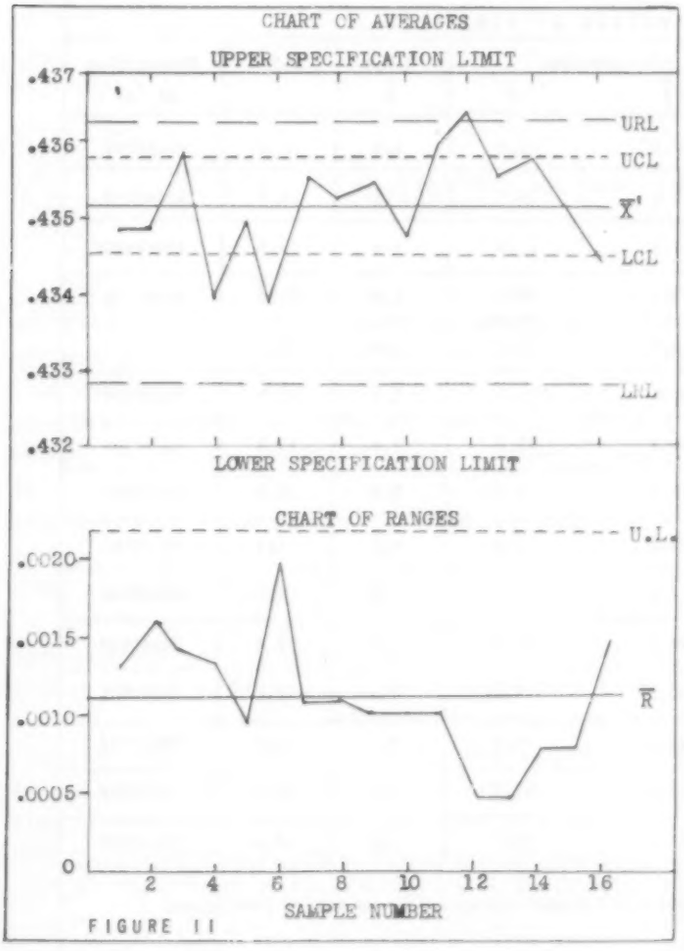


FIGURE II

are shown charts of averages and ranges of an outside diameter measurement taken on samples of five every half hour at a machine producing 200 pieces per hour. R' is .0011 inches. The value of b from Table I for a sample of five is .713 and the value of bR' is .00078. The upper specification limit, 0.4370 inches, minus bR' gives the upper reject limit of 0.4362 inches and the lower specification limit, 0.4320 inches, plus bR' gives the lower reject limit of 0.4328 inches. Reference to Figure II shows lots 3,4,6,12, and 16 outside of the conventional control limits. Lot 12 only is outside the reject limit. The lot from which this sample was taken is the only lot which must be detailed to assure the material will be of acceptable quality.

INSPECTION AT A POINT REMOTE FROM PRODUCTION

Incoming material is commonly inspected 100%, or where sampling plans are in effect, sampling by attributes is employed. Considerable saving with no sacrifice in protection will result in many cases from the use of sampling by variables. The use of the upper and lower reject limits in conjunction with the specification limits provides a means of sampling by variables. A decision must be reached as to whether it is more economical to measure and record values of a small number of pieces or inspect a large quality on a go-not-go basis.

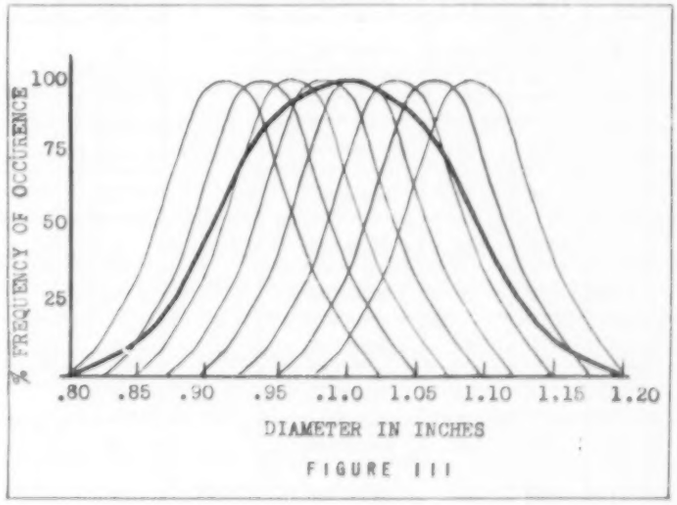


FIGURE III

The frequency distribution of a lot produced over a period of time may be considered as composed of a series of universes. During production these universes shift due to tool wear, change of material, lack of proper process adjustment, etc. Figure III illustrates

a production run of 9000 pieces made in nine successive weeks. The frequency distribution of the production of each week is shown to be normal and the average of the distribution of each successive lot is shown to be higher than the previous one. The distribution of the overall lot is also normal. If the manufacturer of these pieces shipped to one customer one hundred units a day for ten days from his production of the first week and the customer set up charts for averages and ranges based on samples of these lots, he would obtain a false impression of the overall frequency distribution. In other words, the customer does not have enough information about the manufacturing process or the sequence in which the lots are shipped to determine intelligently whether the product is controlled. If the manufacturer resumes shipments to the first customer, say from production of the sixth week, the customer would find data from these lots would be badly out of control with respect to the first lots. He may feel because of the apparent lack of control that inspection by sampling is not safe. This is not necessarily the case. The process illustrated is controlled, but to show that, detailed information of the process is required and sloping control limits must be used.

To pass judgment on material at a point remote from the place of manufacture by using the method of sampling by variables, take m samples of n pieces each from the lot. Regard the average range as the best measure available for the dispersion of the lot. The value of $\bar{\bar{X}}$ will not be needed since the reject limits are computed with respect to the specification tolerances by the use of a factor related to the dispersion (range) of the samples.

The upper specification limit minus $b\bar{R}$ and the lower specification limit plus $b\bar{R}$ will

TABLE II

Inspection of Radio Tubes For Conformance to Maximum Plate Current Specification

METHOD OF ATTRIBUTES				METHOD OF VARIABLES						
Lot No.	Lot Size	Sample Size	Disposition of lot	Sample Size	No. of Samples	Averages $\bar{X}$	Averages $\bar{\bar{X}}$	Range $\bar{R}$	URL	Disposition of lot
1	3550	160	Accepted	5	2	10.8	11.8	2.5	12.8	Accepted
2	1100	135	Accepted	5	2	11.4	10.6	1.2	13.7	Accepted
3	50	22	Accepted	5	2	12.3	11.6	1.4	13.6	Accepted
4	5700	235	Accepted	5	2	12.4	12.0	3.0	12.4	Accepted
5	150	65	Accepted	5	2	13.0	14.2	5.4	10.8	*
6	50	22	Accepted	5	2	12.0	12.6	2.6	12.7	Accepted
7	5700	235	Rejected	5	2	14.4	13.6	4.5	11.4	Rejected
8	50	22	Accepted	5	2	12.0	12.2	2.3	13.0	Accepted
9	5700	235	Rejected	5	2	13.0	11.8	4.5	11.4	Rejected
10	50	22	Accepted	5	2	12.8	13.0	2.3	13.0	Accepted
11	1800	135	Rejected	5	2	14.5	13.5	2.0	13.2	Rejected
12	1450	135	Rejected	5	2	13.5	14.6	3.3	12.2	Rejected
13	2500	150	Rejected	5	2	13.2	14.0	3.1	12.4	Rejected
14	50	22	Rejected	5	2	14.6	13.0	3.6	12.0	Rejected
15	450	60	Rejected	5	2	14.2	14.7	1.9	13.4	Rejected

* Averages of samples exceed the URL. The lot was accepted on the basis of further inspection by method of attributes.

determine the upper Reject Limit (URL) and lower Reject Limit (LRL) respectively which are not to be exceeded by the average values. When the reject limits are exceeded, the lot should be sampled on the basis of attributes and accepted or rejected according to the criteria set up. This precaution is taken due to the possibility of the supplier screening, prior to shipment, all pieces which exceeded the specifications and leaving the averages of the remaining pieces close to the specification limit.

To illustrate the savings and the sensitivity of the method of sampling by variables, Table II is presented. Table II is the incoming inspection record for a radio tube having a maximum specified plate current of 14.6 milliamperes. Of the fifteen lots inspected, by the method of attributes, seven lots were rejected. One thousand six hundred fifty-five tubes were checked on a go-not-go basis. By the method of variables, the same seven lots were rejected. This involved the testing of 150 tubes by taking two samples of five each from each lot. One point to be noted in connection with lot number five is the acceptance of the lot when testing by variables although the average falls outside the reject limit. Following the measurement of the ten tubes, fifty-five additional samples were checked on a go-not-go basis and one tube above specification limits was found. Since one reject met the criterion in effect at the time, the lot was accepted.

The use of inspection by variables has the advantages of lower inspection costs and having available recorded values of the pieces measured for future reference. Although fewer pieces are inspected, greater use is made of the information obtained. As the ranges of the measurements increase, indicating possible trouble in the manufacturing technique, the reject limits are pulled closer to the nominal specified value, thus giving greater protection to the customer. No additional burden is placed upon the producer until material is shipped that is outside the specification limits agreed to.

THE ANALYSIS OF SAMPLING PLANS IN RECEIVING INSPECTION

(Continued from Page 9)

CONCLUSION: This plan is quite simple to operate in a receiving department, but its advantages end there. The greatest fault is the variable protection to both vendor and purchaser, and particularly the fact that the vendor is at the mercy of the purchaser except for very large lots. Conversely, of course, the purchaser is exposed to an unreasonably large risk of accepting poor quality lots when lots of less than 1,000 are received.

The demonstrations have been specific but the methods are general and the conclusions drawn would differ in detail only for other lot sizes. These methods of analysis are equally applicable to other sample percents and defective percents. Other so called simple sampling plans can be analyzed by nominal adjustments of the methods used here.

The important point is the fact that quality control operators must be able to analyze these simple plans in order to convince those in positions of authority that such sampling plans are a cause of plant friction because poor quality material goes into fabrication and assembly: a source of friction between vendor and purchaser because of excessive rejection of good quality material. Once these points have been established, the way is opened for the introduction of a scientific sampling plan which will provide constant protection to both producer and consumer regardless of lot size. A small amount of training of receiving inspection personnel will be necessary, but the rewards in quality stability from use of a scientific plan far outweigh this training cost. The interesting part is the enthusiasm which management exhibits for the new plan once its advantages in operation have been demonstrated.

CONSTITUTION
SOCIETY OF QUALITY CONTROL ENGINEERS
Buffalo, N.Y.

Many members have been added to the Buffalo Society in recent months. Most of these do not possess copies of the Constitution of the Society. Likewise many of the original members have had time to misplace their copies. To bring all members up-to-date in this respect, the Constitution and By-Laws are reproduced, including the Amendment adopted at the Annual Meeting January 15, 1945.

Another purpose may be served by this printing. Several secretaries of other Quality Control Societies have recently requested copies of our Constitution. They are in the process of producing operating instruments for their societies and desire to make use of whatever previous experience is available.

Beyond this is the question of national organization. The time is approaching when some individual or group must accept the responsibility for producing a Constitution for a national organization. It is natural that this group will want to have available the management ideas of the local groups. To be sure, the national Constitution must be more comprehensive than its locally used counterparts. But the national objective should be a reflection of the local objectives. The requirements for membership in the national organization cannot be materially different from these employed locally. Questions of dues, fiscal year, and the like must be worked out so that conflicts are unlikely to arise between national and local. Once the national Constitution is adopted, it will be necessary to amend local instruments to bring them into conformity. It is to be hoped, however, that the national Constitution will be written with proper regard for the necessity of maintaining strong local organization. Perhaps the printing of our Constitution will foster discussion along the lines indicated here.

CONSTITUTION

Article I - Name and Object

1. The name of this organization shall be the Society of Quality Control Engineers.

2. The object of this Society is to collect, analyze and disseminate information concerning Quality Control as applied to industry.

Article II - Membership

1. Active Members shall be those who are actively engaged in, or scientifically trained for, technical aspects of Quality Control.

2. Associate Members shall be those who because of industrial, scientific or collateral interests shall be deemed by the Executive Board to be eligible for Membership.

Article III - Officers

1. The Officers of the Society shall be: President, Vice President, Secretary, and Treasurer, and these along with the retiring President shall constitute the Executive Board.

The Executive Board shall be responsible for the Management of the Society in accordance with the by-laws.

2. Term of office shall be for one (1) year from date of election.

3. Officers shall be elected from and by active Members each year at the annual meeting held at the end of the fiscal year.

Candidates will be chosen by a committee of three (3) active Members appointed by the President one (1) month before the annual meeting. The committee will submit its slate to the Secretary for mailing to all Members at least two (2) weeks prior to the aforesaid meeting.

Article IV - Meetings

At least four (4) technical sessions will be held annually. All meetings will be called by the Executive Board.

Article V - Chapters

The Executive Board may establish a chapter of the Society in any area when such action promises to advance the objects of the Society.

Article VI - Amendments

Amendments to this Constitution may be proposed by any active Member at any regular meeting, and will be submitted for discussion, further amendment, and vote at the next regular meeting following. A two-thirds vote of those present will be required for adoption.

BY-LAWS

1. Membership

Active and Associate Members shall be elected by vote of the Executive Board on nomination of one or more Members.

2. Duties of Officers

(a) The President shall act as Chairman of the Executive Board; shall appoint Committee Chairmen who shall, in their turn, appoint their own committees; and shall be a Member ex-officio of all committees.

(b) The Vice President shall act in the capacity of the President in his absence or at his request.

(c) The Secretary shall maintain Society membership list; conduct general correspondence; issue notices of meetings; keep minutes of all meetings.

(d) The Treasurer shall collect dues; from funds of the Society pay all indebtedness of the Society as approved by the Executive Board; maintain adequate financial records, and shall submit an annual report, such report and his records to be audited by the Executive Board.

3. Dues

Dues of $5.00 will be collected annually at the beginning of the fiscal year from all Active and Associate members.

4. Fiscal Year

The fiscal year shall extend from January 1 to December 31.

5. Amendments to By-Laws

By-laws may be amended at any meeting of the Society by a two-thirds vote of Active Members present.

AMENDMENTS

Amendment I

1. Delete from Article III, Section I the phrase: "and these along with the retiring President shall constitute the Executive Board."

2. Replace by:

The Executive Board shall consist of the officers of the previous year and six members elected by the Society. After 1945, two members will be elected to the Executive Board by the Society each year at its annual meeting to serve for a period of three years. At the annual meeting in January, 1945, the Society shall elect a complete Executive Board of six members, two to serve for one year, two to serve for two years, two to serve for three years. Within two weeks of the annual meeting, the President for the preceeding year shall convene the new Executive Board. At this meeting the Executive Board shall elect from its members the officers of the Society for the current year. In case an officer resigns his position, the Executive Board shall elect his successor from its members. The Executive Board, if necessary, may appoint new member(s) to replace member(s) who have resigned; but, in all cases, such appointment(s) run only until the next annual election at which time the Society shall elect a member(s) to the Executive Board to fill the unexpired term(s). The past presidents of the Society of Quality Control Engineers become permanent honorary members of the Executive Board in addition to the members previously stated.

THE QUALITY HABIT

(Continued from Page 5)

and practical quality discussions among all of the people who directly or indirectly control the over-all quality of product. The cooperation developed by these plans supported by an active, demonstrated interest on the part of the management will gradually train all of your people to acquire the quality habit.

Through the cooperation of an entire organization of people who have acquired the quality habit, you will find that you are in a position to minimize or eliminate old defects faster than new ones arise and thus improve the over-all quality of your product and at the same time increase over-all production through minimizing the production time lost due to scrap.

BUFFALO MEETINGS

January 15 was an important day in quality control in Buffalo. At a noontime luncheon of the Chamber of Commerce, Joseph Manuele, Quality Control Manager, Westinghouse Electric and Manufacturing Company, East Pittsburgh explained the advantages of quality control to an enthusiastic group of 150 members and guests of the Chamber. Mr. Manuele stressed the gain in production and reduction of cost which accompanies the use of quality control procedure.

At 7:45 the same evening Mr. Manuele spoke at the annual meeting of the Society of Quality Control Engineers, Crosby Hall, University of Buffalo. With unlimited time at his disposal Mr. Manuele presented a complete story of quality control operations at Westinghouse copiously illustrated with slides. A question period lasting more than an hour is the best evidence of the value of this meeting.

A few summaries from the main talk and the questions will demonstaate the quality of the discussion:

1. Quality must be built into a product, it cannot be put in by inspectors.
2. If the workmanship is faulty, no amount of inspection will improve the fault.
3. Measurement records tell you how the product is being made: fraction defective records merely tell you how it has been made.
4. Measurement gages are being installed at Westinghouse to replace go-not-go gages as fast as we are able to obtain measurement gages.
5. Statistical quality control is 90% engineering judgment and ordinary horse sense.
6. There is work for the statistician, but most of your control problems, including corrective action, depend upon being able to recognize common sense solutions.
7. "Can I use control procedure on small lot production?" If the order calls for at least two similar pieces, I use first piece, patrol, last piece inspection for control. I would not make a second piece until my inspectors had approved the quality of the first piece.

The business session of the meeting produced the following actions:

1. Approval of the amendment to the Society's Constitution as printed on page 20 of the November issue of INDUSTRIAL QUALITY CONTROL.
2. Election of the following as members of the Executive Board:

Robert Funk, Spencer Lens, (three year term)
Alfred Winterhalter, Colonial Radio (three year term)
Kenneth Conrad, Dupont, (two year term)
Geoffrey Letchworth Jr. Barcalo, (two year term)
Peter Di Paola, Curtiss Wright, (one year term)
Joseph Mitchell, Bell Aircraft, (one year term)

NOTE: The Executive Board met January 25 and elected the following officers for the year, 1945.

President:	Alfred J. Winterhalter
Vice President:	Martin A. Brumbaugh
Secretary:	Vernon Grom
Treasurer:	Peter Di Paola

ROCHESTER MEETINGS

December - 169 members turned out to hear four men, composing a panel, discuss various phases of Quality Control.

Mr. Harry Paddock, Superintendent of Film Quality and Waste Control, Kodak Park, Eastman Kodak Company, discussed "The Quality Habit". His excellent paper appears elsewhere in this months magazine.

Mr. Louis Rive, Quality Control Supervisor, Delco Appliance Division, General Motors, discussed "Quality Control in Action at Delco".

Mr. William Blackmon, Quality Control Supervisor, Stromberg-Carlson Company, presented "Quality Improvement of Purchased Materials".

Mr. Alfred J. Winterhalter, Radio Tube Engineer, Colonial Radio Corporation, Buffalo, discussed "Cost Reduction thru Quality Control".

The thorough questioning from the floor, under the guidance of Dr. Brumbaugh, acting as panel chairman, indicated that this meeting was one of the best of the year.

January - Sampling was the subject under discussion with Mr. Edward M. Schrock, the speaker. One hundred ninety-two men and women representing some 25 different industries were present to hear Mr. Schrock's address on the subject "Fancy, Figures and Facts".

CURRENT PUBLICATIONS AND BIBLIOGRAPHY

A page of each issue of the Journal is devoted to brief reviews of articles on Statistical Quality Control appearing in current publications. Earlier issues of the Journal contain bibliographies of materials published in former years. The purpose is to provide readers with a permanent reference list. In compiling this historical list omissions are inevitable. Assistance from readers by supplying missing references will be appreciated.

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NOTES

Sidney Margolis has been transferred from the Engineering Department to the Quality Control Department at the Montoursville plant of Sylvania Electric Products. He will concentrate on the engineering problems arising in the operation of a control system in radio tube manufacture.

Reinhardt Tober is in charge of the Statistical Quality Control Office of the Buffalo Plant of Bell Aircraft Corporation.

The Houdaille Engineering Division of Houdaille Hershey at Buffalo has started a 15 week in-plant training course in quality control procedure for foremen and supervisors. The instruction is provided by the University of Buffalo.

Walter Parwulski formerly Statistics Engineer in the Quality Control Department of Bell Aircraft Corporation is now with Colonial Radio Corporation as Quality Control Engineer.

Ray Corbett, formerly Production Engineer with Colonial Radio Corporation, is now with the Radio Engineering Department of Westinghouse Electric and Manufacturing Company, Baltimore, Maryland.

The Harrison Radiator Company of Lockport, New York will begin a course in quality control methods for foremen and supervisors. The instruction will be provided by the University of Buffalo.

At the end of December, Sylvania Electric Products Corporation completed the second set of courses in quality control for supervisors. These courses are planned jointly by J.R. Steen, Director of Quality Control and Robert Manhart, Director of Training. The courses are sponsored by the E.S.M.W.T. Extension Division of Pennsylvania State College and the instruction is provided by Martin A. Brumbaugh. About 50 members of the Sylvania staff at Williamsport and Emporium attended. The value of this cooperative training plan appears in two directions. Healthy quality control operations are underway in both plants and the coverage within the plants is being expanded constantly. In addition members of the class have developed so much interest in the background of quality control procedure that they are ready for additional training.

Miss Lois Obenauer recently left her position as statistician at Colonial Radio Corporation to become the bride of Seaman Second Class Bylenok.

Mr. Joseph Mitchell recently accepted a position with Sylvania Electric Products Company at Warren, Pa. He was formerly employed by the Bell Aircraft Corporation.

INDUSTRIAL QUALITY CONTROL

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Buffalo 14, New York

THE SOCIETY OF QUALITY CONTROL ENGINEERS

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